

## Prevalence of *Salmonella* spp. and *Escherichia coli* On U.S. Livestock Operations

### Summary

*Salmonella* and *Escherichia coli* (*E. coli*) are associated with significant morbidity and mortality in livestock and therefore are two of the most economically significant pathogens of livestock. In humans, *Salmonella* and *E. coli* are important causes of food-borne illness. The Centers for Disease Control and Prevention (CDC) estimates 1.4 million *Salmonella* cases with 600 deaths occur each year. Morbidity and mortality from *Salmonella* leads to significant economic losses to the population through medical expenses and decreased productivity. Since antimicrobial drugs are used in livestock to control these two pathogens, there is concern about antibiotic resistance development in these pathogens and subsequent transfer of that resistance to humans through contaminated food. The prevalence of these two pathogens in livestock therefore may impact the level of antibiotic use, antibiotic resistance development and human food-borne disease. This concern provides impetus for thoroughly understanding the ecology and epidemiology of *Salmonella* and *E. coli* infections in animals.

The objective of this report is to provide an abbreviated review of *Salmonella* and *E. coli* infections, and present the descriptive results of several national studies by the USDA's National Animal Health Monitoring System (NAHMS) of *Salmonella* and *E. coli* on U.S. livestock operations. *Salmonella* were found in animals on dairy, feedlot, and swine operations. None of the *Salmonella* serotypes from feedlot cattle were among the CDC's list of the top 5 *Salmonella* isolates from humans in 1991. However, three of the serotypes from swine were among the CDC's list of the top 5 *Salmonella* isolates from humans in 1994. *E. coli* O157:H7 was detected in dairy calves and feedlot cattle, but the prevalence generally was low in comparison to the prevalence of some other pathogens. Diseases in swine that may be caused by *E. coli* were reported to be an important cause of morbidity and mortality on swine operations.

### *Salmonella*

Salmonellosis is a ubiquitous disease caused by members of the genus *Salmonella* (Nietfeld et al., 1999). There are more than 2300 serotypes of *Salmonella*. Clinically, salmonellosis in pigs may be systemic, enteric, or inapparent, and may be acute or chronic. *Salmonella choleraesuis* is associated with acute septicemia and enterocolitis, and it accounts for 70% to 90% of all serotypes isolated from clinically ill pigs. *Salmonella typhimurium*, the second most common serotype of pigs, causes acute enterocolitis. *S. dublin*, *S. typhimurium*, *S. newport*, *S. montevideo*, and *S. anatum* are important serotypes of dairy and beef cattle. *S. dublin*, once confined to cattle in the Pacific northwest in the U.S., is becoming more widespread geographically. Salmonellosis in lambs is most prevalent in feeders. *S. abortus ovis* is associated with abortion in ewes. Salmonellosis in goats is reported to be similar to salmonellosis in cattle.

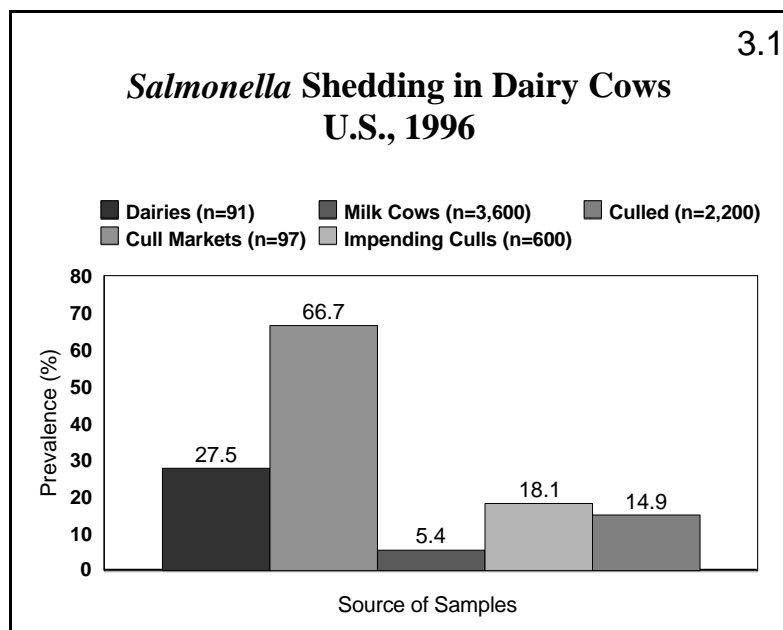
*Salmonella* spp. are some of the most common food-borne pathogens of humans (Roberts, 1988; Bean, 1990). The estimated costs of food-borne illness of bacterial origin in the U.S. is \$2.9 to 6.7 billion annually (Buzby, 1995; Buzby, 1996). Estimated costs associated with human salmonellosis are nearly one billion dollars annually (range 0.6 to 3.5 billion). Beef, dairy, pork,

poultry, and seafood are documented vehicles for transmission of *Salmonella* from animals to humans during these outbreaks (Bean, 1990). Thus, animals that shed *Salmonella* may become a source of human infections. Of no less concern, is the potential transfer of antimicrobial resistant *Salmonella* spp. or their resistance determinants from animals to humans (World Health Organization, 1997). Accordingly, several national epidemiologic studies of *Salmonella* in U.S. livestock populations were undertaken to provide a scientific basis for addressing relationships between the infections in humans and animals.

## Descriptive Epidemiology of *Salmonella* in the U.S.

### *Dairy Cows*

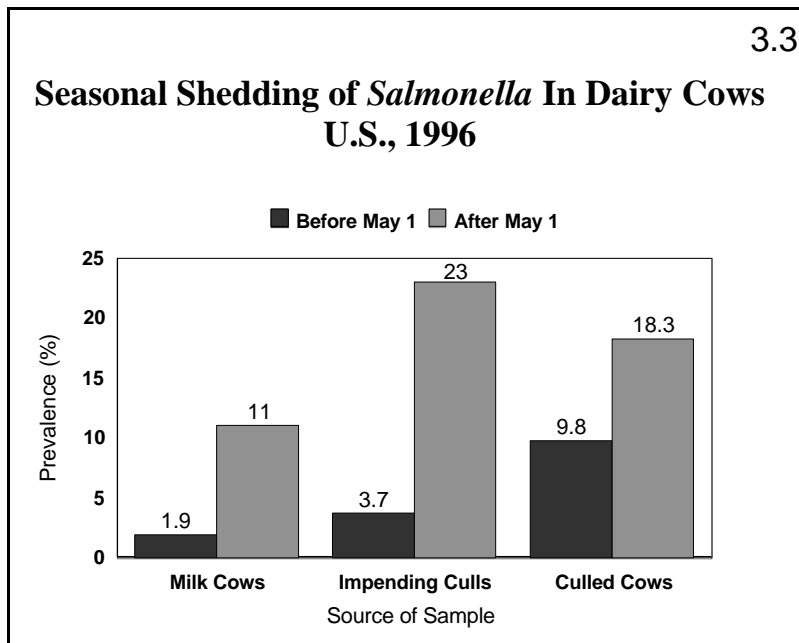
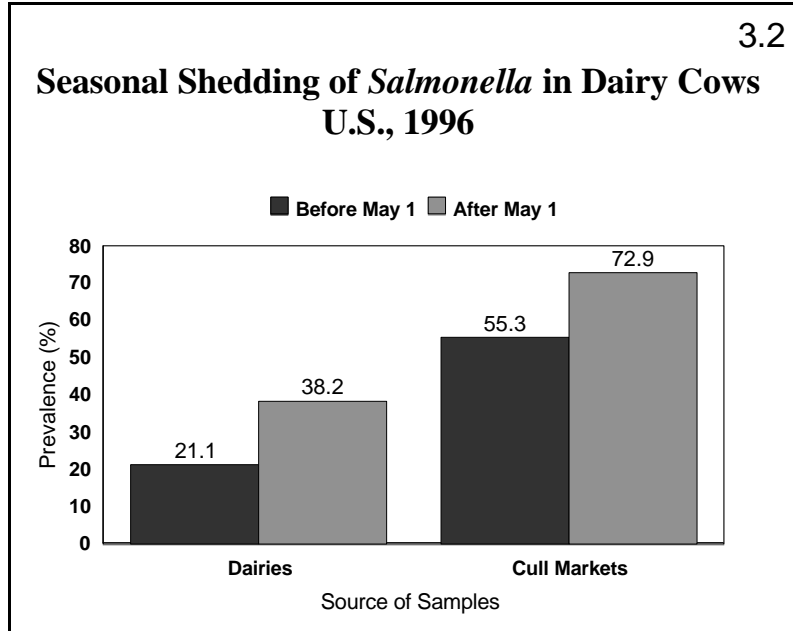
A survey of *Salmonella* was included in the NAHMS Dairy '96 Study (USDA/APHIS/VS, 1998). Fecal samples were collected from a total of 4,200 cows, 3,600 milk cows and 600 impending cull cows (i.e., 7 days prior to culling), on 91 dairy operations in 19 states. Samples also were collected from 2,000 dairy cows from 97 cull-cow markets. The operation prevalence of fecal shedding of *Salmonella* on dairy operations and in cull-cow markets was 27.5% and 66.7%, respectively (**Figure 3.1**). The individual-cow prevalence in milk cows and cull cows



from these operations and markets was only 5.4% and 14.9%, respectively. The operation prevalence of shedding was higher during the three-month period after May 1, 1996 versus the three-month period before May 1 (**Figure 3.2**). Similarly, the individual-cow prevalence of shedding was higher during the three-month period after May 1, 1996 versus the three-month period before May 1 (**Figure 3.3**).

### *Dairy Calves*

A national study of the prevalence of *Salmonella* in U.S. dairy calves was done in 1991-1992 (USDA/APHIS/VS, 1994). Dairy producers from 28 states were selected to represent herds of

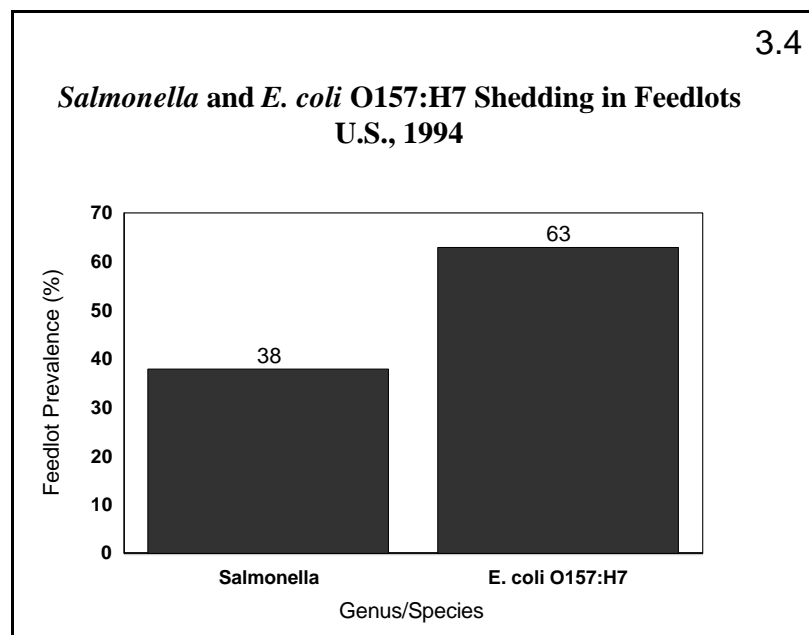


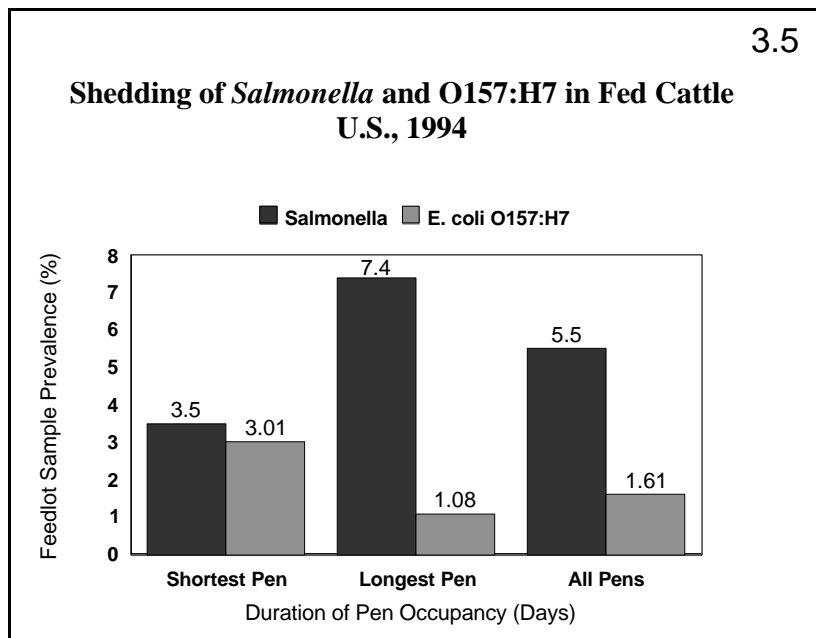
30 or more cows and also represent 78% of the National dairy cow population. Producers were given the option of having fecal specimens evaluated for *Salmonella*. The prevalence of *Salmonella* in specimens from 6,862 calves was 2.1%. The most prevalent serotype was *S. typhimurium*, which comprised 27.6% of 145 positive samples. *S. dublin* comprised 10.3% of the positive samples. Other serotypes were *S. mbandaka*, *S. muenster*, *S. anatum*, *S.*

*cerro*, and *S. typhi copenhagen*. The geographic distribution of the infection was widespread, but the region-specific prevalence was highest in the south, where 34.1 were positive per 1,000 specimens tested. The prevalence was lowest in the northeast region, 15.0 per 1,000 specimens. The prevalence was highest in herds of 100-plus cows (25.0 positives per 1,000 specimens) and lowest in herds of 51 to 100 cows (11.9 positives per 1,000 specimens).

### *Feedlot Cattle*

During the NAHMS 1994 Cattle on Feed Evaluation (COFE), a stratified random sample of feedlot operations from the 13 leading cattle-feeder states was selected for COFE (USDA/APHIS/VS, 1995). The number of operations that responded was 498, and 100 of the 498 operations with a capacity of at least 1,000 cattle volunteered to have samples collected from their feedlots. In each feedlot, 25 samples were collected from fresh feces on the floor of two pens, one pen having the shortest duration of occupancy, and the other pen having the longest duration of occupancy. A total of 4,977 samples from 200 pens on the 100 operations were tested for *Salmonella* at the National Animal Disease Center. The operation prevalence was 38.0%, and the sample prevalence was 5.5% (**Figures 3.4 and 3.5**). Shedding of *Salmonella* was more prevalent in southern feedlots. *Salmonella* was more prevalent on operations and in pens that were classified as having a “long-duration of occupancy” by the cattle versus those that were classified as having a “short-duration of occupancy” by the cattle (**Figure 3.5**). A single serotype was found on 42.1% of the 38 positive operations, and multiple serotypes were found on the remaining 57.8% of the positive operations. The five most common serotypes were *S. anatum*, *S. montivideo*, *S. muenster*, *S. kentucky*, and *S. newington*. Unlike swine (refer to discussion below), none of the serotypes from the 1994 COFE were among the CDC’s list of the top 5 *Salmonella* isolates from humans in 1991.





### Swine

During the NAHMS Swine '95 Study, 160 swine operations were selected to participate in a survey of *Salmonella* in finisher hogs (USDA/APHIS/VS, 1997). The NAHMS Swine '95 study included pork operations in 16 states that contained 91% of the U.S. hog inventory. A total of 6,655 samples that were collected from 988 pens on 152 operations were tested for *Salmonella* at the National Animal Disease Center. A "positive", regardless of whether reference is being made to an operation or a pen, was defined as one with at least one positive sample, and these "positives" were used to determine the operation prevalence, pen prevalence and sample prevalence.

The operation prevalence of *Salmonella* was 38.2%. The prevalence varied among 3 distinct geographic regions from 29.9% to 65.5%. The trend of increasing herd size continues in the swine industry, and unfortunately, *Salmonella* shedding was more prevalent on large operations. The pen prevalence of *Salmonella* in the 998 pens was 17.5%. Of the 10 pens sampled per farm, the prevalence was from 10% to 100%. The sample prevalence in the 6,655 samples was 6.0%. The 10 most frequent serotypes that are shed by finisher hogs accounted for 85.0% of the isolates from Swine '95. A single serotype was found on 60.3% of the positive operations, and multiple serotypes were found on the remaining 39.7% of the positive operations. Four of the serotypes are on the CDC's list of the top 10 *Salmonella* isolates from humans. Carcass contamination as a possible source of these human isolates is a concern of the CDC, regardless of whether the isolates are susceptible or resistant to antibiotics.

### *Escherichia coli*

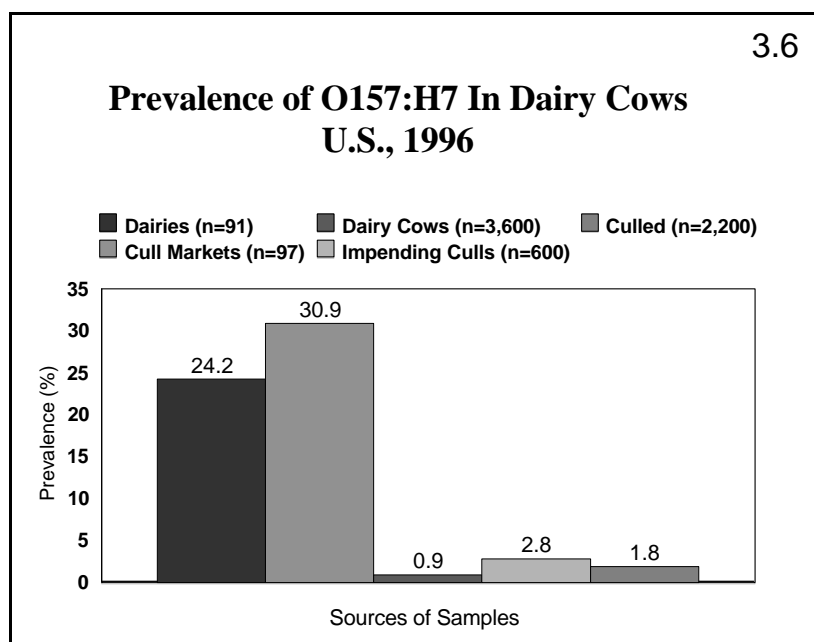
Most mammalian species are susceptible to *Escherichia coli* infections (Fairbrother, 1999). The most frequent clinical manifestations of *E. coli* infection are neonatal and postweaning diarrhea

(i.e., scours) and edema disease in young pigs, dysentery, septicemia in young calves and lambs, and mastitis in adult cattle (Fairbrother, 1999). The most important pathotypes in livestock are enterotoxigenic, verotoxigenic, attaching and effacing, septicemic, and nonsepticemic extraintestinal *E. coli*. Strains of a restricted number of subgroups are pathogenic. These strains are classified into pathotypes, based on the production of virulence factors. For example, the enterotoxigenic *E. coli* (ETEC) pathotype is associated with diarrhea in farm animals, and the enterohemorrhagic *E. coli* (EHEC) pathotype is associated with bloody diarrhea in humans. *E. coli* are classified into 150 to 200 serogroups. The predominant serogroup of EHEC that is associated with human disease is O157:H7. Interest in *E. coli* O157:H7 has grown since the large human outbreak in the western U.S. in 1993. Food items such as ground beef, dry fermented sausage, unpasteurized milk, and apple juice, and also nonchlorinated water and recreational water, are vehicles for transmission of O157:H7 (USDA/APHIS/VS, May 1997). Antibiotic resistance genes also have been traced from *E. coli* in animals to *E. coli* in humans (World Health Organization, 1997). Several national epidemiologic studies of *E. coli* in U.S. livestock populations were undertaken, as they were undertaken with *Salmonella*, to provide a scientific basis for exploring the relationships between the infections in animals and humans.

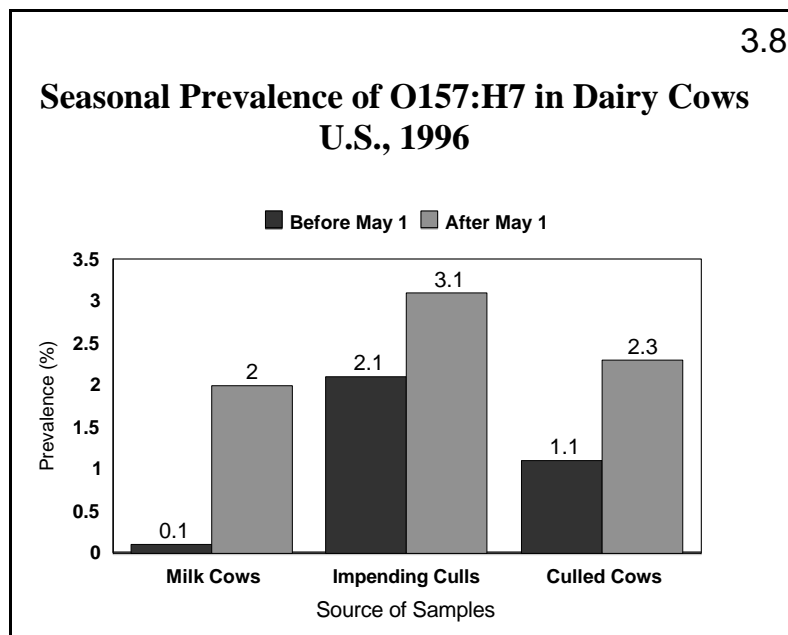
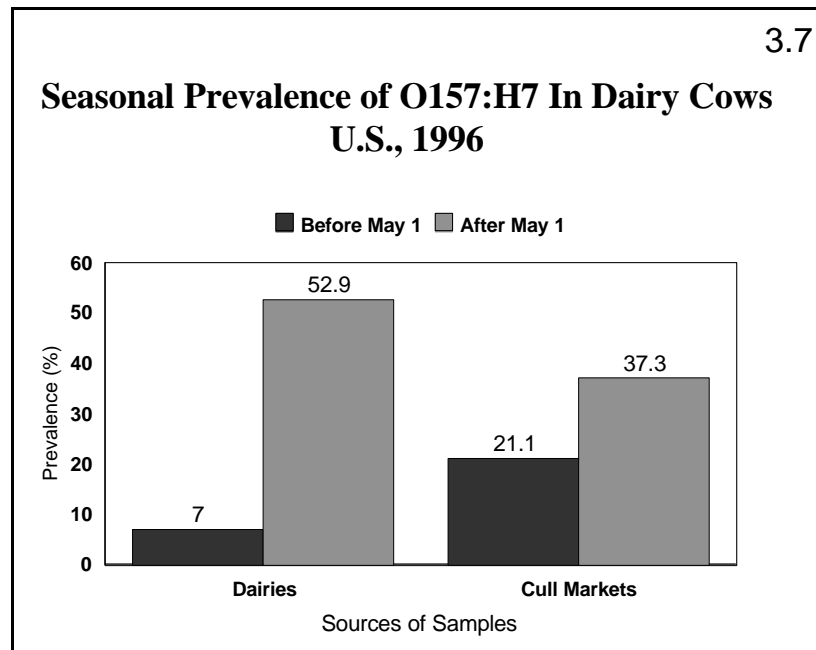
### Descriptive Epidemiology *Escherichia coli* O157:H7

#### *Dairy Cows*

A survey of *E. coli* O157:H7 also was included in the NAHMS Dairy '96 Study (USDA/APHIS/VS, 1998). Fecal samples were collected from a total of 4,200 cows, 3,600 milk cows and 600 impending cull cows (i.e., 7 days prior to culling), on 91 dairy operations in 19 states. Samples also were collected from 2,000 dairy cows from 97 cull-cow markets. The operation prevalence of fecal shedding of verotoxigenic *E. coli* O157:H7 on dairy operations and in cull-cow markets was 24.2% and 30.9%, respectively (**Figure 3.6**). However, the



individual-cow prevalence in dairy cows and cull cows was only 0.9% and 2.8%, respectively. Regardless of the low prevalence, it has been shown that nearly all dairy operations will be positive for O157:H7, if samples are collected from the operations repeatedly (Hancock et al., 1997). As with *Salmonella*, the operation prevalence of fecal shedding of O157:H7 was higher during the three-month period after May 1, 1996 versus the three-month period prior to May 1 (Figure 3.7), and the individual-cow prevalence of fecal shedding was higher during the three-month period after May 1, 1996 versus the three-month period prior to May 1 (Figure 3.8).



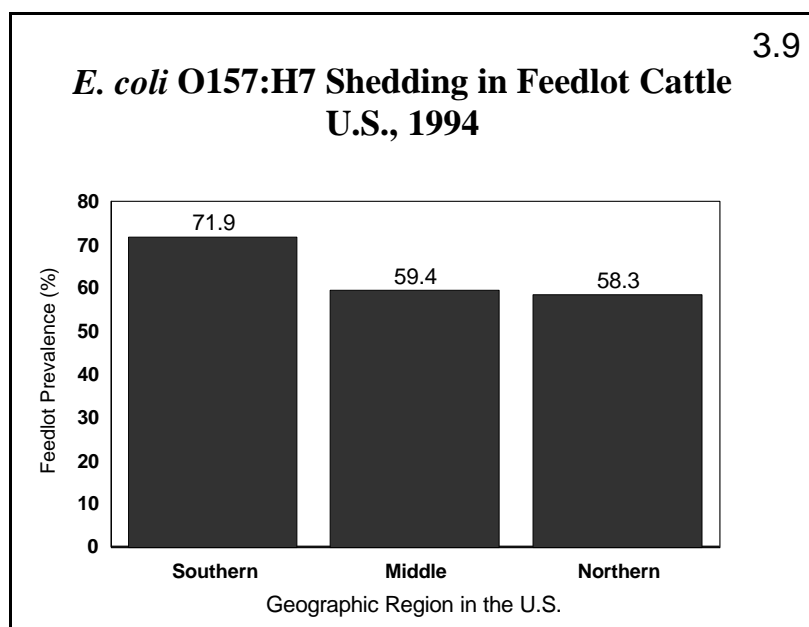
The operation prevalence of fecal shedding of O157:H7 was 39.1% in herds with 100 or more milk cows and 8.9% in smaller herds. Given that the size of dairy herds, like swine herds, is increasing, the potential implications of a higher prevalence of O157:H7 in larger herds should be of concern.

### *Dairy Calves*

A national study of the prevalence of *Escherichia coli* O157:H7 in U.S. dairy calves was done in 1991-1992 (USDA/APHIS/VS, 1994). The National Dairy Heifer Evaluation Project (NDHEP) included 1,811 dairy operations from 28 states. The operations were selected to represent herds of 30 or more cows and also represent 78.0% of the National dairy cow population. The prevalence of O157:H7 in specimens from approximately 7,000 calves was 3.6%. The geographic distribution of the infection was widespread and rather evenly distributed. A prospective study of 64 of the original herds, 50 of which were negative, showed that the status of the infection for a given herd may change. Infected calves were found on 22.0% of the 50 negative herds, as well as 50% of the herds that were positive originally. The prevalence of infection was higher in weaned calves.

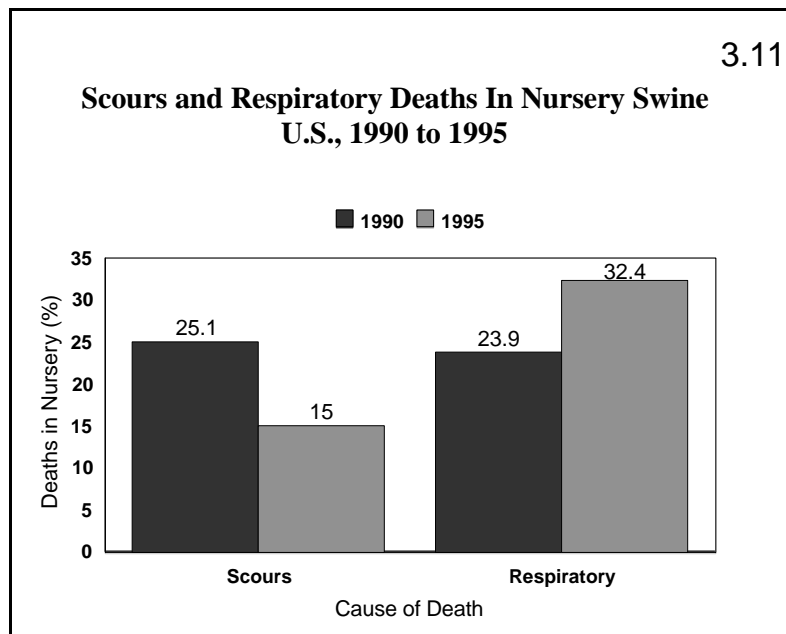
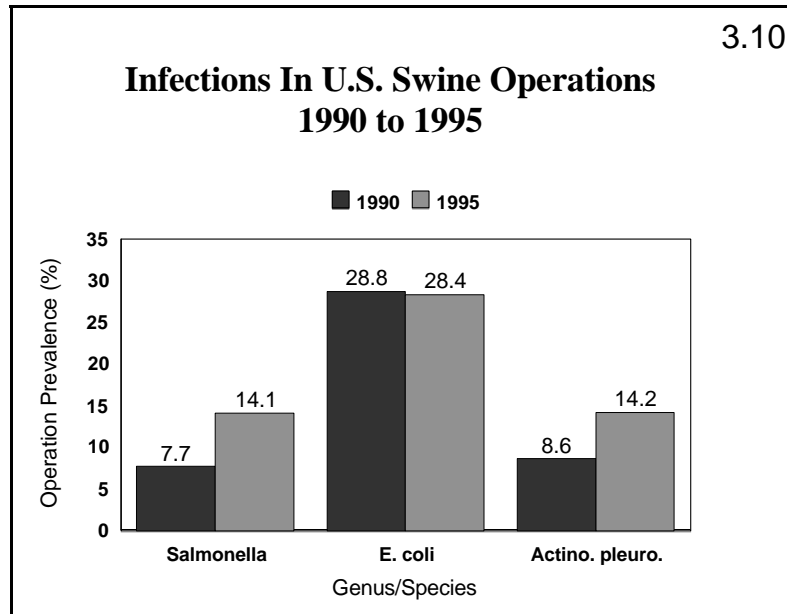
### *Feedlot Cattle*

A survey of O157:H7 also was included in the NAHMS 1994 Cattle on Feed Evaluation (COFE) (USDA/APHIS/VS, 1995). In each feedlot, 30 samples were collected from fresh feces on the floor of two pens, one pen having the shortest duration of cow-occupancy, and the other pen having the longest duration of occupancy. Two additional pens were selected randomly for sampling, if available. A total of 11,881 samples from 400 pens on the 100 operations were tested for O157:H7 at the National Veterinary Services Laboratory and Washington State University. The operation prevalence of O157:H7 was 63.0%, and the sample prevalence was 1.61% (**Figures 3.4 and 3.5**). The operation prevalence was at least 12% higher in the Southern region (**Figure 3.9**). *E. coli* O157:H7 was more prevalent on operations and in pens that were classified as having a “short-duration of occupancy” versus those that were classified as having a





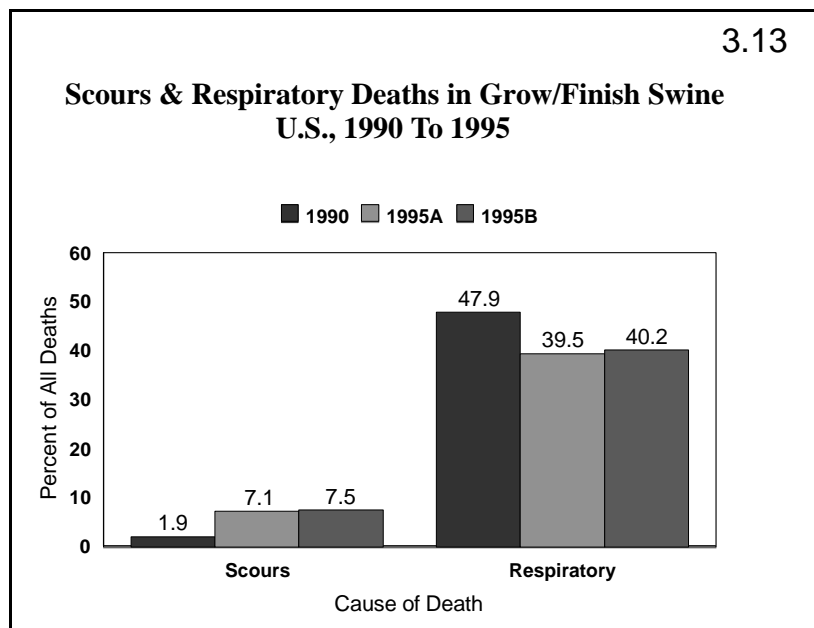
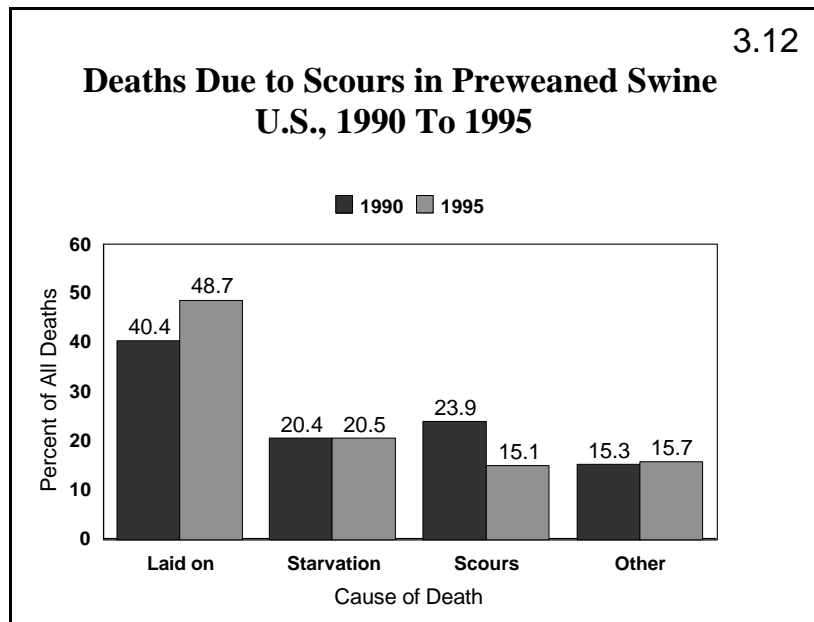
“long-duration of occupancy” (**Figure 3.5**). The sample prevalence within a pen (i.e., 30 samples) was from 0.0% to 36.7%. The ability to produce the toxins that contribute to human disease was found in all the isolates. The conclusion from NAHMS COFE '94 was that O157:H7 is widespread geographically, but the prevalence of O157:H7 is low when compared to other pathogens.



## Descriptive Epidemiology of Colibacillosis

### Swine

Colibacillosis-type diseases were studied in national surveys of U.S. swine (USDA/APHIS/VS, 1997e). Diseases in U.S. swine operations that were attributed to *E. coli* were two to four times more prevalent than diseases that were attributed to *Salmonella* and *Actinobacillus* (Figure 3.10). Scours was associated with 25.1% and 15.0% of deaths in nursery swine in the U.S. in 1990 and 1995, respectively (Figure 3.11). Similarly, scours was associated with 23.9% and 15.1% of deaths in preweaned swine in the U.S. in 1990 and 1995, respectively (Figure 3.12).



While the proportion of operations that attributed deaths in preweaned and nursery swine to scours decreased from 1990 and 1995, the proportion of operations that attributed deaths in grow/finish swine to scours increased (**Figure 3.13**).

A study to determine whether or not *E. coli* O157:H7 is present in the U.S. market hog population was conducted as part of the NAHMS Swine 95 survey. A total of 4,229 swine fecal samples collected from 152 randomly selected pork operations in the 6 top swine-producing states were tested for *E. coli* O157:H7, and none were positive (USDA/APHIS/VS, 1996).

## **Conclusion**

Many previous reports of the prevalence of *Salmonella* and *E. coli* O157:H7 infections in U.S. livestock frequently have been restricted to localized geographic regions. One advantage of epidemiological studies by the NAHMS is that the studies are designed to provide national estimates of the prevalence of various pathogens. Infections by *Salmonella* and *E. coli*, or diseases related to these two pathogens, were detected at various levels on dairy, feedlot, and swine operations in the U.S. The prevalence of *Salmonella* shedding in dairy calves and in swine was higher in larger herds. The prevalence of *E. coli* O157:H7 shedding in dairy cows was also higher in larger herds. This suggests that herd-size as a risk factor for pathogen shedding, along with management factors associated with herd size, should be investigated further. Although the prevalence of antibiotic resistance was not a part of the studies reported here, the National Antimicrobial Resistance Monitoring System - Enteric Bacteria, has been organized to conduct surveillance for resistance in these two pathogens as well as others (Tollefson, 1998).

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